Candidal infections and populations of *Candida albicans* in mouths of diabetics

LM TAPPER-JONES, MJ ALDRED, DM WALKER, TM HAYES*

*From the Department of Oral Medicine and Oral Pathology and the *Department of Medicine, Welsh National School of Medicine, Heath Park, Cardiff*

SUMMARY   The prevalence of oral candidosis and the frequency of isolation of *Candida albicans* and its density and distribution have been determined in the mouths of 50 patients with diabetes mellitus and 50 healthy volunteers matched for age, sex, dental status and smoking habits. Three of the diabetic patients were found to have a chronic oral candidosis. According to an imprint culture technique, the oral carrier rate and density of *C albicans* were both higher in the diabetic group as a whole than in the control subjects. Smoking was associated with an increased prevalence of the yeast in diabetes mellitus. Diabetics wearing dentures had higher candidal density than those without a prosthesis. No differences in candidal status could be detected according to the degree of control of diabetes, mode of treatment, duration of diabetes or the patient's age. Local factors such as smoking and the presence of dentures, particularly when worn continuously, interact with diabetes mellitus in promoting candidal colonisation of the mouth. Attention to these predisposing factors could reduce the incidence of thrush in diabetics.

Although Winner and Hurley[1] state that patients with diabetes mellitus are susceptible to thrush, no clinical survey of diabetics to establish the incidence of candidal infection in the mouth has been done. Moreover, previous accounts do not agree as to whether *Candida albicans* is[2 3] or is not[4 5] more prevalent in the mouths of diabetics than in non-diabetics. These conflicting reports may reflect the fact that local factors such as denture wearing and smoking which significantly influence oral candidal populations[6 7] were not considered by most previous investigators. The method of sampling also seems important. Earlier workers sampled only saliva[3 4] but if many oral sites are investigated using imprint cultures, *C albicans* can be isolated only from the tongue in as many as one-third of dentate carriers.[7] According to Odds *et al.*,[8] the degree of control of the diabetes significantly influenced the extent of oral yeast colonisation but again local factors were ignored.

Our study describes the prevalence of candidal infection in the mouths of diabetic patients. With the imprint culture technique, the frequency of isolation of *C albicans* and its intraoral density and distribution were assessed in the diabetic patients and age- and

sex-matched controls of similar dental status and smoking habits. We have attempted to relate these parameters to the degree of diabetic control.

Patients, material and methods

The diabetic group comprised 50 randomly chosen outpatients attending a hospital diabetic clinic who were already receiving treatment for their diabetes mellitus. The control group comprised 50 healthy volunteers matched for age, sex, dental status and, whenever possible, smoking habits. Each subject's mouth was examined. An imprint culture technique was used to determine the frequency of isolation and density of *C albicans* at up to twelve intraoral sites, as described previously[7] except that the foam pads dipped in Sabouraud's broth used to sample each site were applied to the mucosal or denture surface for 30 s rather than one minute. Yeasts were identified as *C albicans* by standard mycological methods.[7] Diabetic control was assessed by the system of Odds *et al.*[8] who classified the degree of control as good, moderate, or poor on the basis of blood glucose concentrations and urinalysis. To relate our results with the imprint culture technique to those of Odds *et al.*[8] who used a mouthwash technique, samples were taken by both methods in the final 15

Table 1 *Sex, age, dental status and smoking habits in fifty diabetics and fifty healthy controls*

Group	No	Sex		Mean age (yr)	Age range (yr)	Dental status		Smoking habits	
		M	F			Dentate	Denture wearers	Smoker	Non-smoker
Diabetics	50	24	26	52·5	17-79	17	33	19	31
Controls	50	24	26	52·7	21-79	17	33	21	29

consecutive diabetic patients in our series.

Statistical analysis

The results were assessed using Student's t test, paired and unpaired, and the χ^2 test where appropriate.

Results

The diabetic and control groups were well matched in terms of age, sex, dental status, although slightly fewer of the diabetics were smokers (Table 1).

ORAL EXAMINATION

Three (6%) of the diabetic patients had clinical evidence of chronic oral candidal infection. All wore dentures, one had a candidal denture stomatitis affecting the palatal mucosa, while the other two

patients had an atrophic glossitis and bilateral angular cheilitis. These patients were haematologically normal. Two of these three wore their dentures overnight and were tobacco smokers. Clinically, none of the controls had candidal infection.

ORAL CANDIDAL POPULATIONS

Thirty (60%) of the 50 diabetic patients carried *C albicans* at one or more sites compared with 21 (42%) of the healthy controls (Fig. 1), but the difference in frequency of isolation was not significant. The mean overall candidal density was significantly higher in the diabetic patients than in the controls (Fig. 1) both when the groups are compared as a whole and for the candidal carriers in each group considered separately. The clinical diagnosis of chronic oral candidosis in the three diabetic patients was confirmed in each case by imprint cultures with confluent growth of *C albicans* being obtained from the affected site.

C albicans was detected more frequently in the diabetics than the controls in eleven out of twelve intraoral sites sampled (Fig. 2), and this difference was statistically significant on the anterior tongue, palate, commissures, and floor of mouth. The fitting surface of the lower denture was the only site at which this trend was not observed. Diabetic patients who were candidal carriers harboured the yeast in higher densities at all sites than control carriers, and the differences were significant at most sites (Fig. 3).

EFFECT OF DENTAL STATUS

When the diabetic patients were subdivided according to their dental status, only in the dentate subjects was the frequency of candida isolation significantly higher than in the controls (Fig. 4). There was little difference in the mean candidal density amongst dentate diabetics and non-diabetics. Of the 33 diabetic denture wearers, 17 wore their prostheses continuously and 70% of these had positive cultures, while only 44% of those who removed their dentures at night were carriers.

EFFECT OF SMOKING HABITS

Fig. 5 illustrates that smoking increases the candidal carrier rate both in diabetics and controls. Four out of every five diabetics who smoked carried the
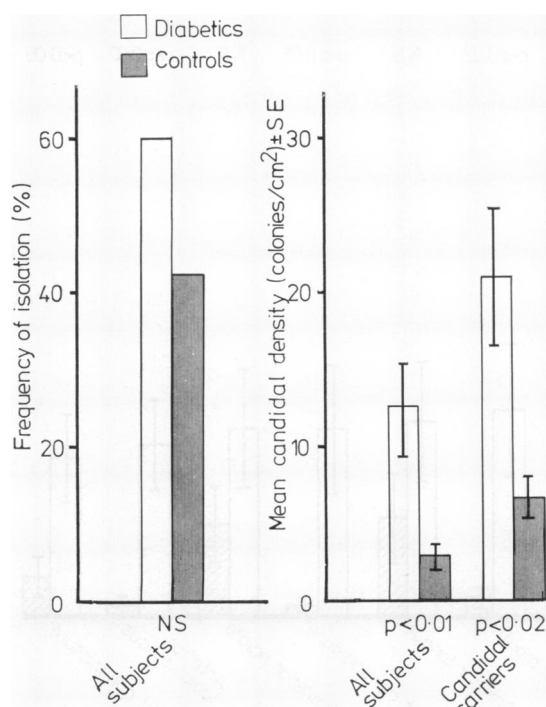

Fig. 1 *Frequency of isolation of Candida albicans and mean candidal density in fifty diabetic patients and fifty healthy controls.*
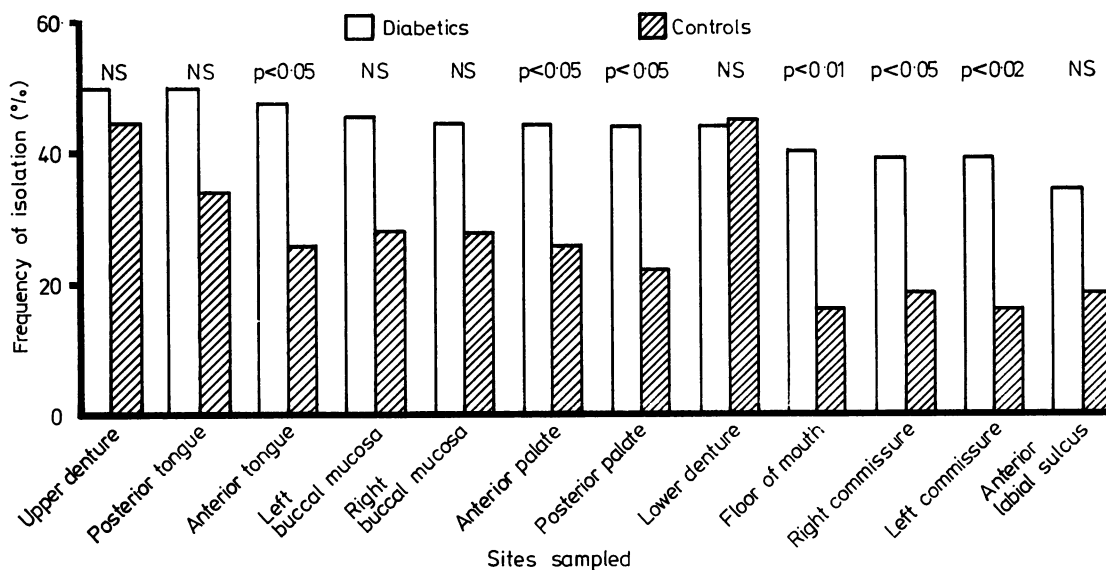
Fig. 2   *Frequency of isolation of Candida albicans at various sites in fifty diabetic subjects and fifty controls.*
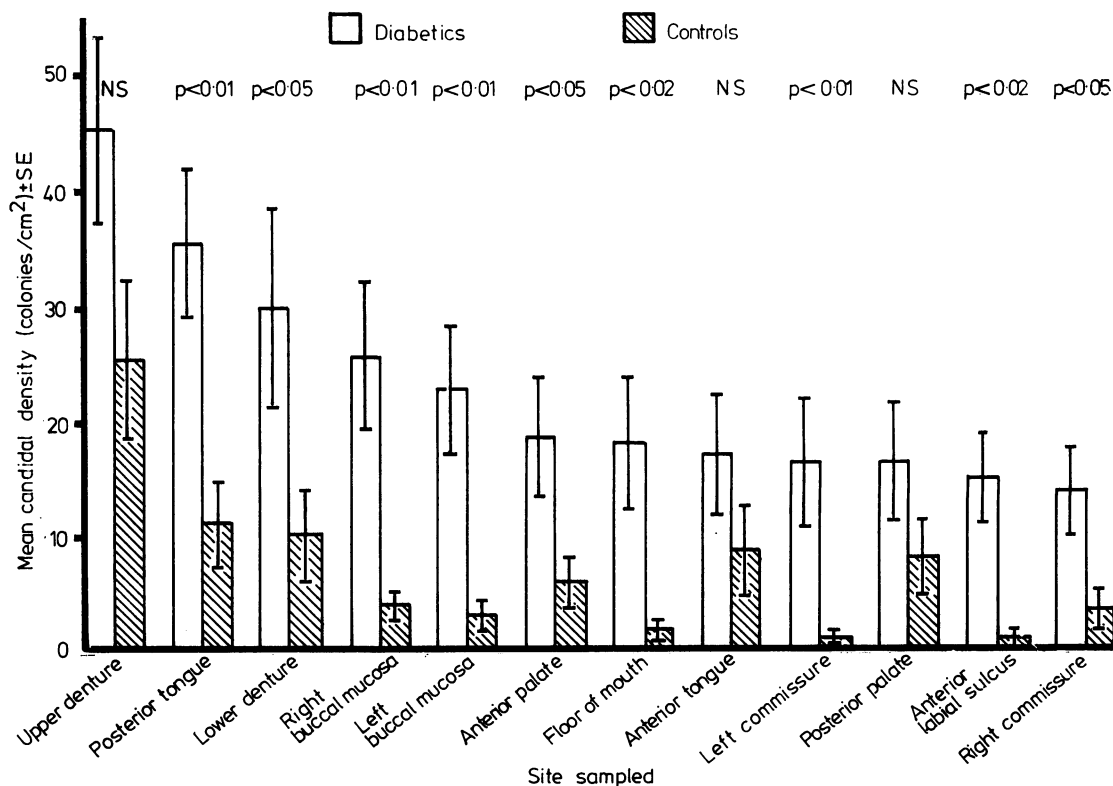

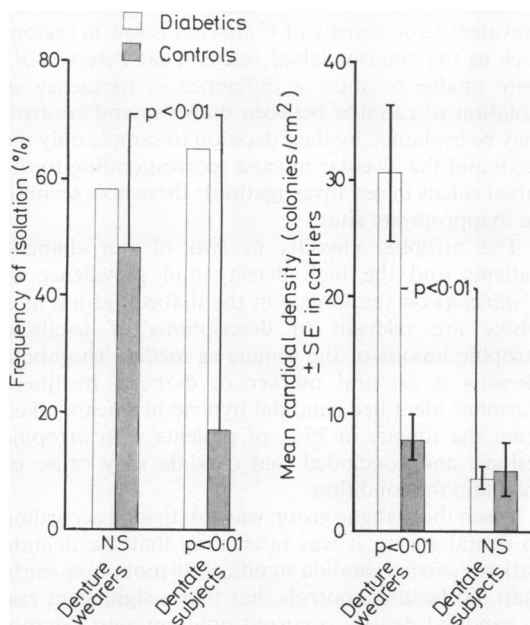Fig. 3   *Mean candidal density at various intraoral sites in diabetic and control candidal carriers.*

Fig. 4 *Relation between denture wearing, frequency of isolation, and mean candidal density.*
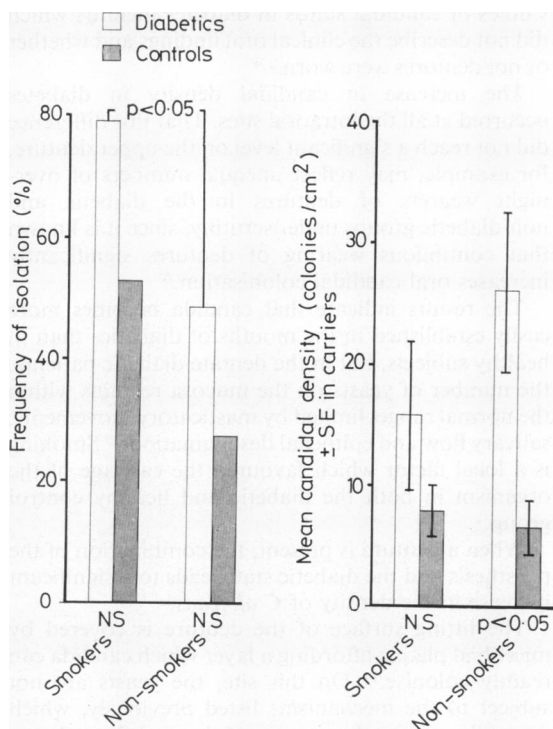

Fig. 5 *Relation between smoking, frequency of isolation, and mean candidal density.*

yeast. Smoking did not significantly influence the overall candidal densities in either group however. Neither the mode of treatment (Fig. 6) nor the degree of diabetic control (Fig. 7) significantly influenced either the prevalence or the density of *C albicans* in the diabetic patients under scrutiny. The apparently low candidal density in the patients with moderate control should not be over-emphasised since there were only 5 such patients. No correlation was found between the age of the diabetics or the duration of their diabetes and the carrier rate or candidal density in the mouth.

Finally, imprint cultures appear to be more sensitive than the mouthwash technique for detecting carriers of *C albicans* (Table 2).

Discussion

The present investigation has confirmed and extended the report of Barlow and Chattaway[2] that *C albicans* is more prevalent in the mouths of a group of diabetics than in those of healthy controls. By also swabbing the skin, anal canal and vagina for candida, Barlow and Chattaway[2] detected only a
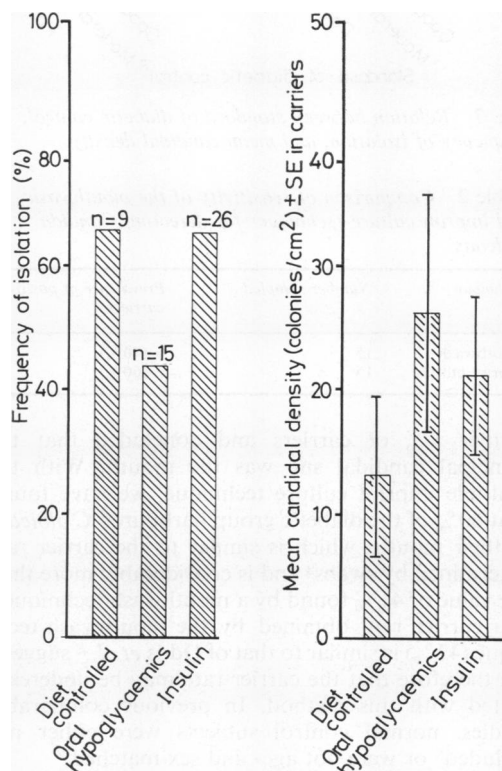

Fig. 6 *Relation between mode of treatment, frequency of isolation, and mean candidal density.*
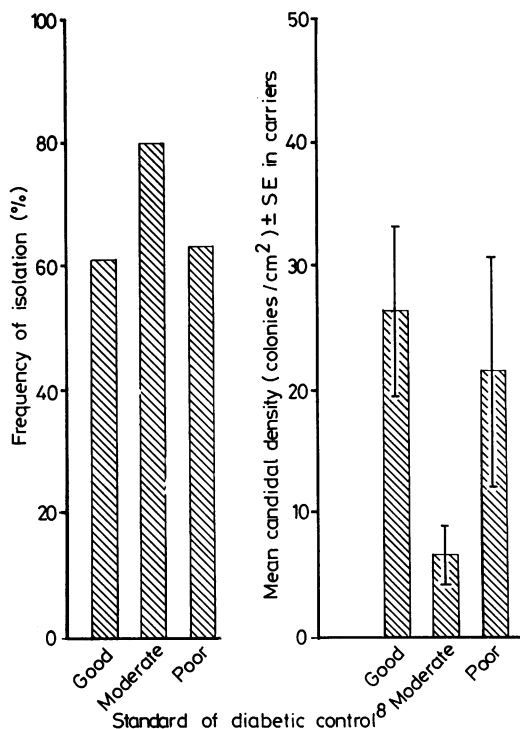
Fig. 7 *Relation between standard of diabetic control, frequency of isolation, and mean candidal density.*

Table 2 *Comparison of sensitivity of the mouthwash and imprint culture techniques for detecting Candida albicans*

Technique	Number sampled	Prevalence of positive carriers
Mouthwash	15	6 (40%)
Imprint culture	15	9 (60%)

further 8% of carriers and concluded that the principal candidal site was the mouth. With the multiple imprint culture technique, we have found that 60% of the diabetic group harboured *C albicans* in their mouths which is similar to the carrier rate determined by swabs[2] and is considerably more than the value of 41% found by a mouthwash technique.[8] Our carrier rate obtained by the mouthwash technique (42%) is similar to that of Odds *et al.*,[8] suggesting therefore that the carrier rate may be underestimated with this method. In previous comparable studies, normal control subjects were either not included[8] or were not age- and sex-matched.[2]

C albicans is not uniformly distributed in the mouths of healthy people;[7] this also applies in diabetes mellitus according to our survey of twelve

intraoral sites. In diabetes mellitus, as in health, the prevalence and density of *C albicans* is low in regions such as the anterior labial sulcus. That Peters *et al.*[5] were unable to show a difference in frequency of isolation of candida between diabetics and controls may be explained by their decision to sample only the teeth and the alveolar mucosa (corresponding to the labial sulcus in our investigation); these now seem to be inappropriate sites.

The atrophic glossitis in two of our diabetic patients and the high density and prevalence of *C albicans* on the tongue in the diabetic group as a whole are relevant to descriptions of localised atrophic lesions of the tongue as median rhomboid glossitis is an oral marker of diabetes mellitus.[9] Farman[9] identified candidal hyphae in smears taken from the tongue in 25% of patients with atrophic lesions, and concluded that candida may cause or maintain the condition.

When the diabetic group was subdivided according to dental status, it was interesting that the dentate patients carried candida significantly more frequently than did healthy controls, but that a significant rise in candidal density occurred only amongst denture wearers with diabetes. The differences dependent on presence or absence of a prosthesis tend to invalidate studies of candidal status in diabetes mellitus which did not describe the clinical oral findings and whether or not dentures were worn.[2] [4]

The increase in candidal density in diabetes occurred at all the intraoral sites. That this difference did not reach a significant level on the upper denture, for example, may reflect unequal numbers of overnight wearers of dentures in the diabetic and non-diabetic groups under scrutiny, since it is known that continuous wearing of dentures significantly increases oral candidal colonisation.[6]

The results indicate that candida becomes more easily established in the mouths of diabetics than in healthy subjects, but in the dentate diabetic patients, the number of yeasts on the mucosa remains within the normal range, limited by masticatory movements, salivary flow and epithelial desquamation.[10] Smoking is a local factor which favoured the carriage of the organism in both the diabetic and healthy control group.[7]

When a denture is present, the combination of the prosthesis and the diabetic state leads to a significant increase in the density of *C albicans*.

The fitting surface of the denture is covered by microbial plaque affording a layer which candida can readily colonise.[11] On this site, the yeasts are not subject to the mechanisms listed previously, which normally restrict the density of the oral flora. From this primary reservoir, *C albicans* is carried in the saliva to other sites.

A hypothesis that diabetes mellitus is not in itself usually responsible for significant increases in candidal populations, but only when interacting with a local factor, is supported by our findings in the three diabetic patients with candidal infection. All wore dentures, and two of these patients were smokers who wore their dentures day and night. All three patients had well-controlled diabetes as classified by Odds *et al.*[8]

We were unable to confirm the observation[8] that patients with poorly-controlled diabetes carried yeasts more frequently and in higher numbers than those with moderate or good control. Differences in sampling techniques or in dental status and smoking habits (data not given by Odds *et al.*[8]) between patients in these two investigations may account for the contradictory findings. The series of Odds *et al.*[8] also included inpatients who might have received antibiotics, unlike any of our outpatients. In agreement with Odds *et al.*,[8] however, no relation has been found between the mode of treatment and the oral candidal populations.

Why oral yeasts are commoner and more numerous in diabetes mellitus is not known. That these parameters were not related to the degree of diabetic control or to the type of diabetic treatment does not support the suggestion of Knight and Fletcher[12] that susceptibility to thrush in diabetes results from raised glucose concentrations in the tissue fluid.

Our investigation has, however, disclosed local factors which act in a cumulative manner upon the presence and density of *C albicans* in the mouths of diabetics. Since a minimum density of the yeasts is necessary for candidal infection to occur,[13] attention to these predisposing local factors might reduce the risk of thrush in diabetics.

References

[1] Winner HI, Hurley R. *Candida albicans*. London: J & A Churchill, 1964.

[2] Barlow AJE, Chattaway FW. Observations on the carriage of *Candida albicans* in man. *Br J Dermatol* 1969;**81**:103-6.

[3] Weinstein IW, Duke LB, Peters RS, Bahn AN. *Candida albicans* in the saliva of diabetics. *J Dent Res* 1960;**39**: 656.

[4] Mehnert B, Mehnert H. Yeasts in urine and saliva of diabetic and non-diabetic patients. *Diabetes* 1958;**7**:293-7.

[5] Peters RB, Bahn AN, Barens G. *Candida albicans* in the oral cavities of diabetics. *J Dent Res* 1966;**45**:771-7.

[6] Arendorf TM, Walker DM. Oral candidal populations in health and disease. *Br Dent J* 1979;**147**:267-72.

[7] Arendorf TM, Walker DM. The prevalence and intra-oral distribution of *Candida albicans* in man. *Arch Oral Biol* 1980;**15**:1-10.

[8] Odds FC, Evans EGV, Taylor MAR, Wales JK. Prevalence of pathogenic yeasts and humoral antibodies to candida in diabetic patients. *J Clin Pathol* 1978;**31**:840-4.

[9] Farman AG. Atrophic lesions of the tongue: A prevalence study among 175 diabetic patients. *J Oral Pathol* 1976;**5**: 255-64.

[10] Gibbons RJ, van Houte J. Bacterial adherence in oral microbial ecology. *Annu Rev Microbiol* 1975;**29**:19-44.

[11] Budtz-Jorgensen E. Hibitane in the treatment of oral candidiasis. *J Clin Periodontol* 1977;**4**, suppl 5:117-28.

[12] Knight L, Fletcher J. Growth of *Candida albicans* in saliva; stimulation by glucose associated with antibiotics, corticosteroids and diabetes mellitus. *J Infect Dis* 1971; **123**:371-7.

[13] Wain WH, Price MF, Cawson RA. Factors affecting plaque formation by *Candida albicans* infecting the chick chorioallantoic membrane. *Sabouraudia* 1976;**14**: 149-51.